MÜLLER-BBM
ACOUSTIC SOLUTIONS

m|multimic

MICROPHONE ARRAY FOR SPATIAL AVERAGE LEVEL DETERMINATION AT THE DRIVER'S HEAD POSITION

OBJECTIVE MEASUREMENT RESULTS | **REPEATABLE SET-UP** | **GOAL-ORIENTED ACOUSTIC EVALUATION**

multimic -FEATURES

- Fast set-up
- Repeatable installation
- Reliable and reproducible measurement results
- Significant reduction of the confidence range for frequencies above 500 Hz
- Optimal relationship between the number of microphones and the space encompassed by the measurements
- Goal-oriented acoustic evaluation of vehicle interiors

multimic - APPLICATIONS

- Roller dynamometer for the evaluation of tyre and engine noise
- eMobility – evaluating comfort levels of electric drive trains
- Engineering mechatronic components, e.g. ventilation noise, operation noise
- Quality assurance – End-of-line testing
- Tunnel transits
- Evaluating acoustic signals
- Laboratory test-bench set-ups

THE CHALLENGE

Common practice in the measurement of sound pressure levels at the head position of the driver of a vehicle typically involves using single microphones, microphone pairs, head-worn microphones, or dummy-head microphones. Typical applications include measurement of tyre noise, motor noise, the sounds made by mechatronic components and tunnel transits, and the evaluation of acoustic signals.

Reproducing measurements in this context often proves to be extremely difficult. The measured levels depend on the condition of the vehicle, the position of test-stand rollers, and so on. Additionally, in the middle and high frequency range, the exact position of the measurement microphone plays a key role. This position is determined by the position and adjustment of the seat, and the mounting of the microphone. Even a small difference in the microphone position has a considerable effect on the measured level. For instance, a narrow band spectrum analysis with a band-width of 8 Hz will typically show a standard deviation of approx. $\sigma = 5$ dB. The variation arises statistically due to interference effects at the measurement position. As a result, not only the reproducibility, but more importantly the validity of one or two randomly chosen microphone positions is very questionable. The solution to this problem is spatial averaging.

THE SOLUTION

Müller-BBM has developed a dedicated microphone array to cater for the specific challenges of measurement within a vehicle. The mount allows optimal positioning of the minimum number of microphones required for accurate, repeatable results. Collectively, the microphones encompass a volume corresponding to the range of possible ear positions for different sized persons in different sitting positions.

The required number of microphones and their positions were optimised for the smallest possible deviation in measurement results via special correlation functions developed on the basis of in-vehicle measurements at the driver's head position.

The in-vehicle measurements revealed that the correlation functions related to noise from the motor (figure 1), the tyres, or airflow, barely differ from one another. The correlation functions were determined along various axes starting at the head position (towards the windscreen, towards the passenger position, and so on). Within the designated head area, the direction had no significant influence. Therefore, a universal function "approximation" with a gradient similar to the correlation function in a diffuse sound field can be used to optimise the microphone position.

THE SET-UP AND MEASUREMENT PROCESS

The integrated height and angle indicators allow reproducible installation of the multimic microphone array. Six mounting points with microphone clamps allow fast and simple mounting of any standard size 1/2" measurement microphone. Two cables connect the array to the measurement front-end. The front-end systems MKII and MicroQ from Müller-BBM are particularly well suited to this application. Measurements are taken in the conventional manner, whereby the six microphone signals are individually recorded. Subsequently, the energetic mean of the sound pressure levels is calculated.

Experience has shown that even quite large variations in the position of the array produce barely any change in the mean sound pressure level. When measuring with the multimic array, the confidence range of the SPL at the driver's head position (95%) is significantly reduced in comparison to measurements made with two microphones or with a dummy-head (Figure 2). A marked improvement is possible in the frequency range above 500 Hz, which is increasingly relevant with the increase in importance of electric drive trains (Figure 3). An accurate acoustic assessment of a vehicle is possible with a minimum of effort.

Figure 4 shows the confidence range determined from an acceleration/deceleration analysis of an electric vehicle. The sound pressure level was measured at six microphone positions using the multimic array. The prognosis shown in figure 2 corresponds well with the experimental results shown in figure 4.

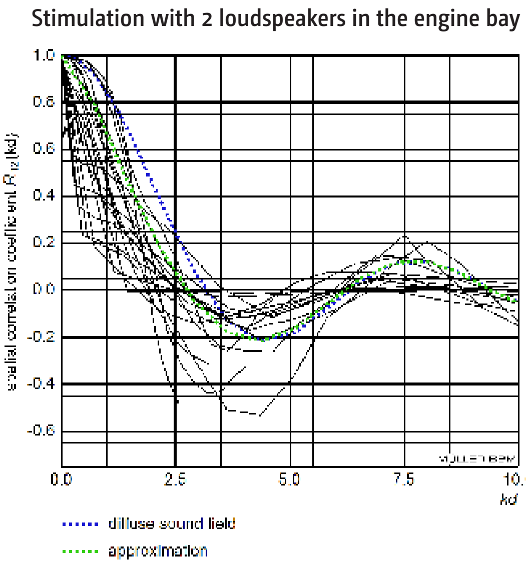

Figure 1
Spatial correlation function of the sound pressure level between 50 Hz and 6.3 kHz from the product of the number of waves and the distance between two microphones in the head area of the driver's seat.

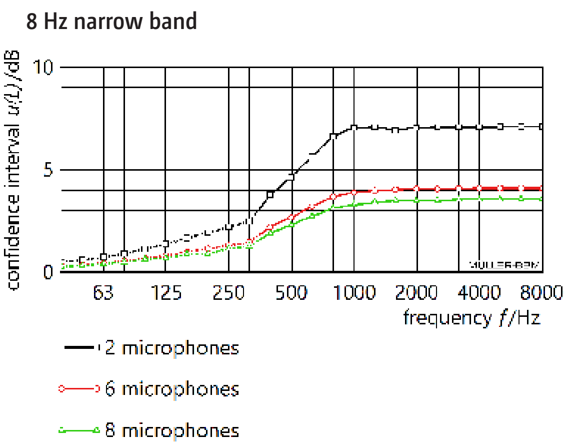

Figure 2
Confidence range of the sound pressure level using the multimic array with six and with eight microphones compared to that using two microphones separated by the distance between a person's ears. Measured with noise as the stimulus and using narrow band analysis with 8 Hz band-width.

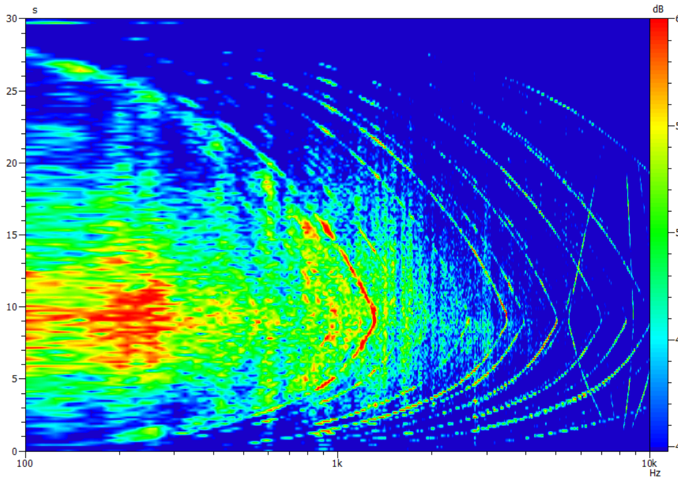

Figure 3
APS of the sound pressure level at the driver's ear in a vehicle with an electric drive train.

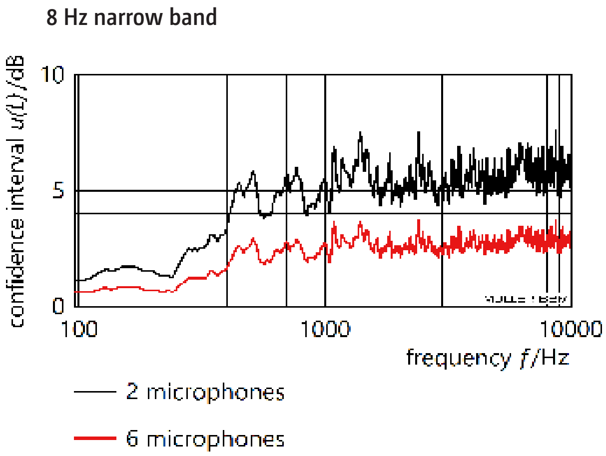

Figure 4
Confidence range of the sound pressure level during an acceleration/deceleration analysis in an electric vehicle, determined empirically using the multimic microphone array.

Figure 5
Angle and height indicators on the multimic microphone array.

Contact Details

Müller-BBM Acoustic Solutions GmbH
Helmut-A.-Müller-Str. 1 - 5, 82152 Planegg, Germany
Tel. +49-89-85602-700
E-Mail: info@mbbm-aso.com
www.mbbm-aso.com